The Use of Landsat 8 for Monitoring of Fresh and Coastal Water

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By Javier A. Concha

07-06-15

Hypothesis

- “The L8 sensor can be utilized to simultaneously quantify the concentration of water constituents (specifically chlorophyll, suspended solids, and colored dissolved organic matter) in fresh and coastal waters.”

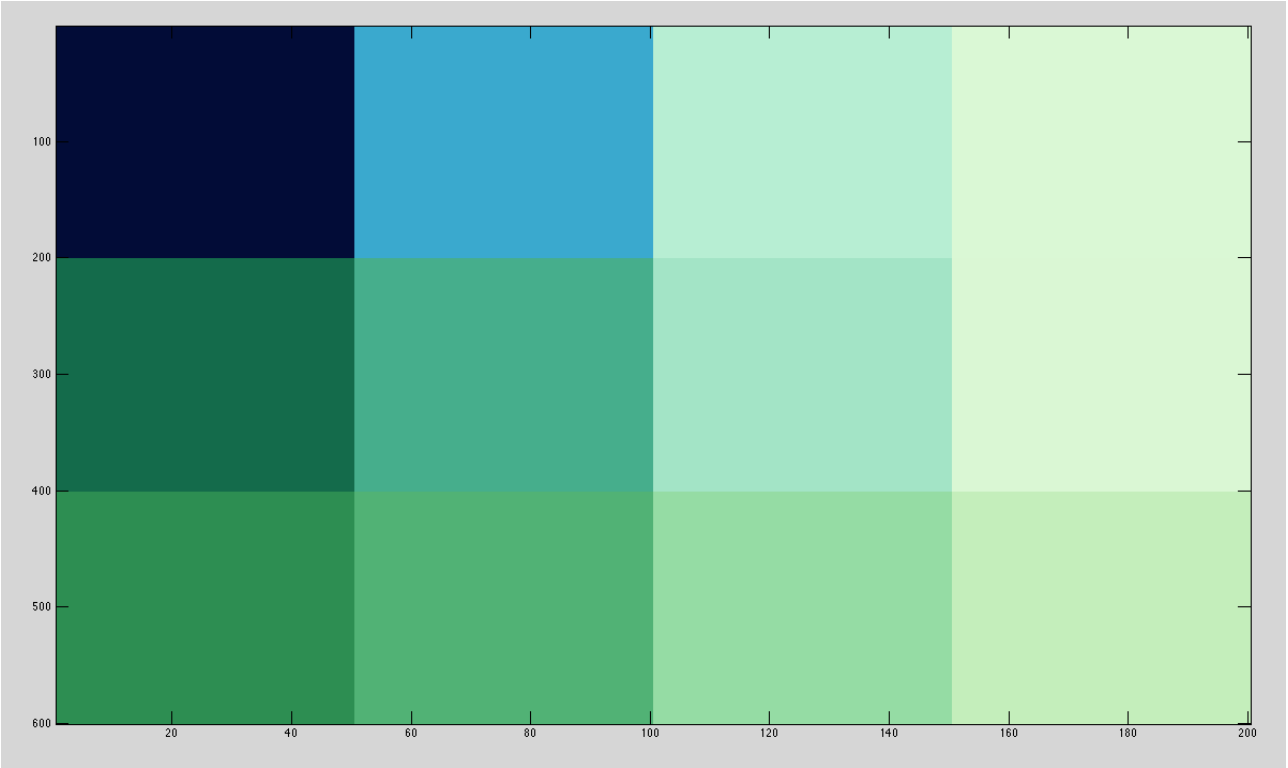
CDOM fixed = 0.0954 1/m

TSS=0.01 TSS=9.11 TSS=30.7 TSS=50.0

CHL=0.01

CHL=25.0

CHL=60.0



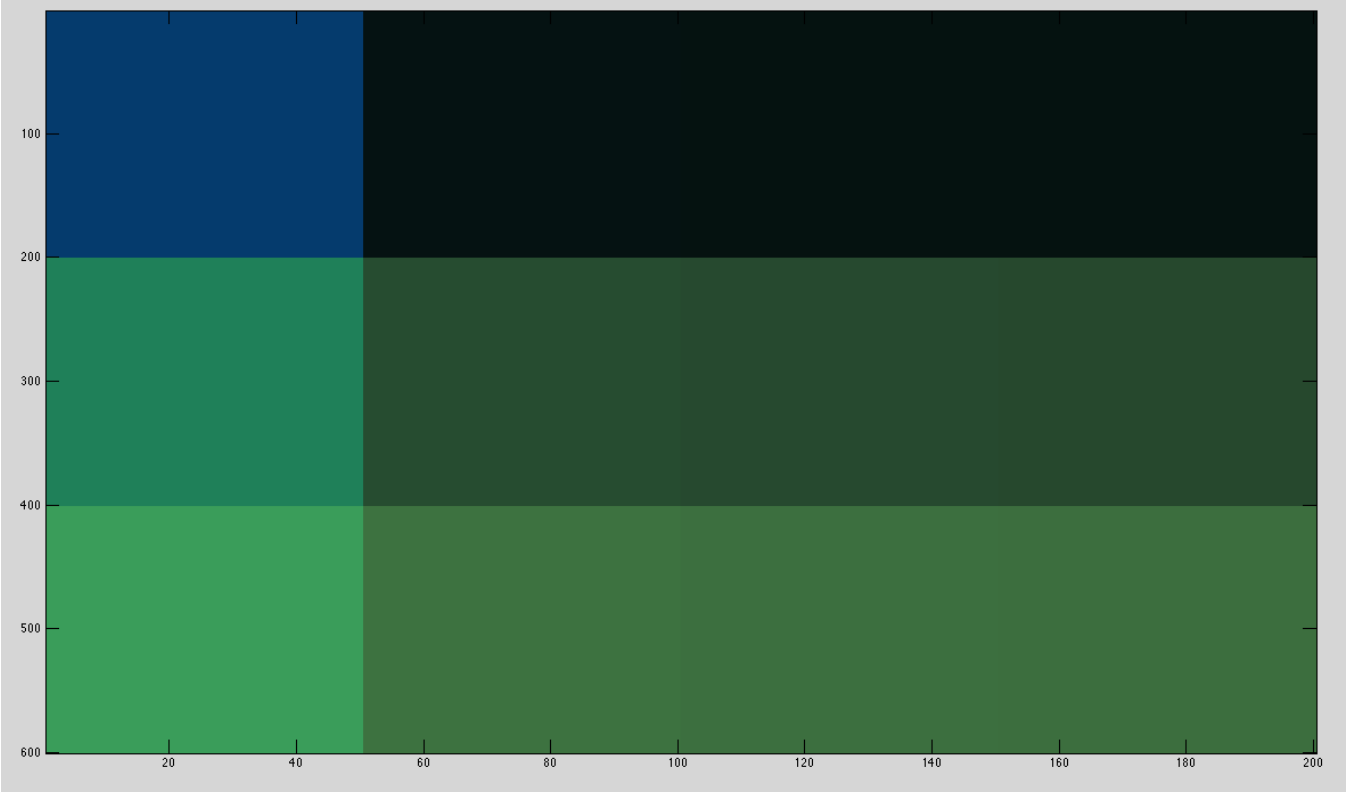
TSS fixed = 1.4 g/m^3

CDOM=0.0954 CDOM=0.9297 CDOM=1.0025 CDOM=1.0194

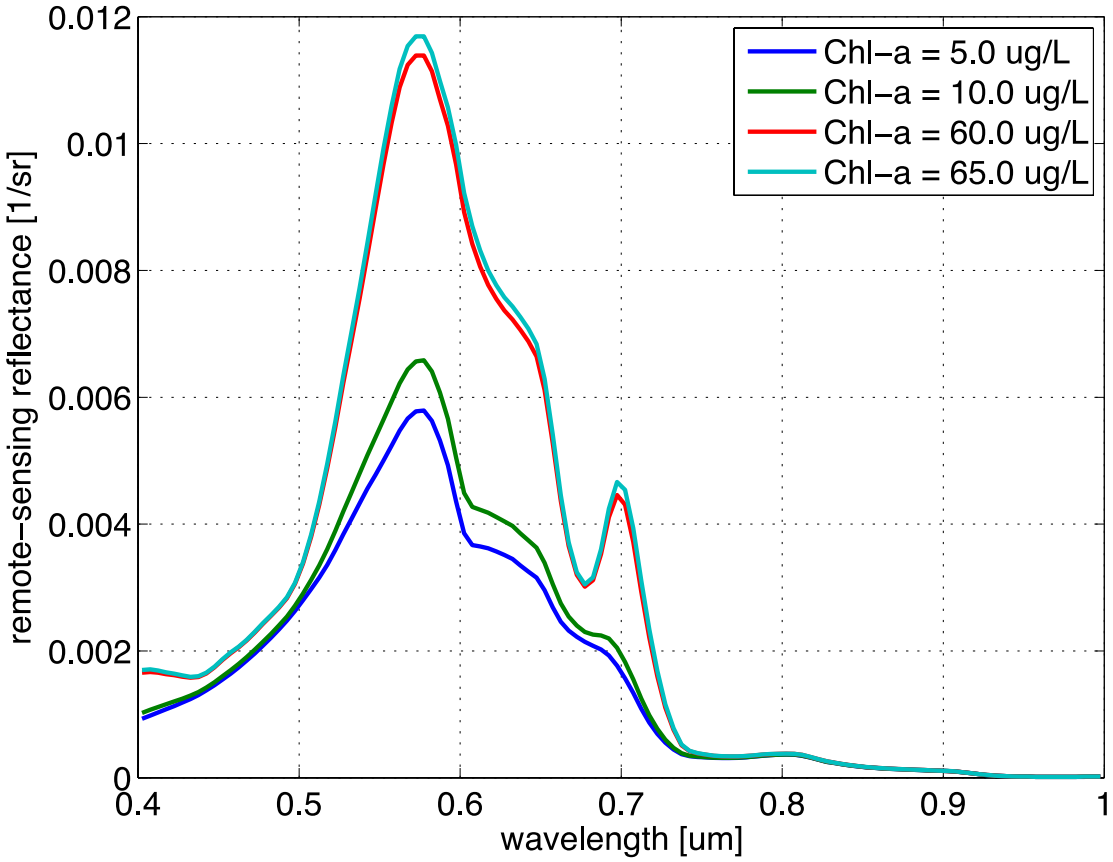
CHL=0.01

CHL=25.0

CHL=60.0



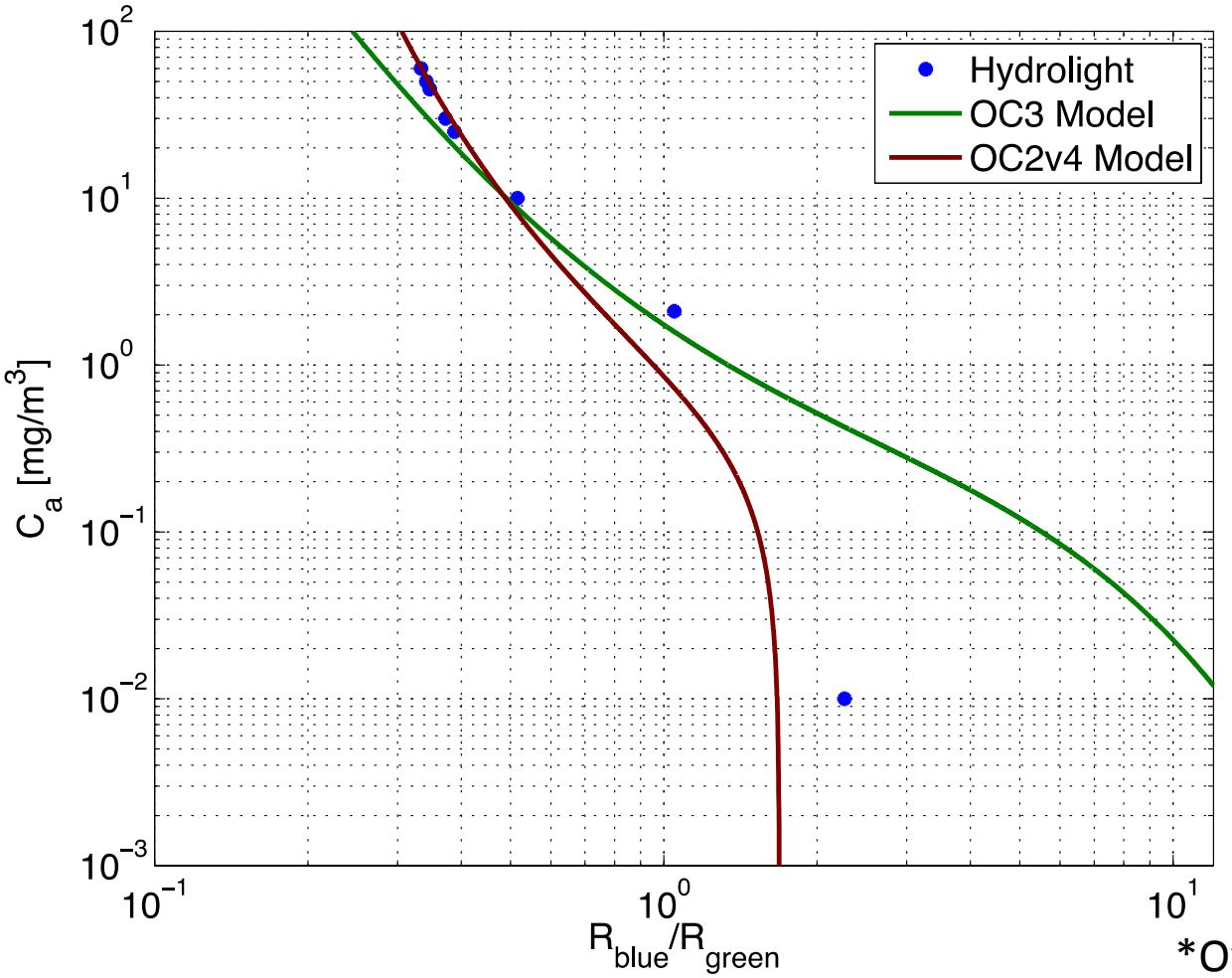
Differences in Rrs with low and high Chl-a concentrations



TSS = 5.0 mg/L

a_CDOM(440)=0.9819 1/m

NASA's OCx Models* vs Hydrolight everything fixed but chl-a

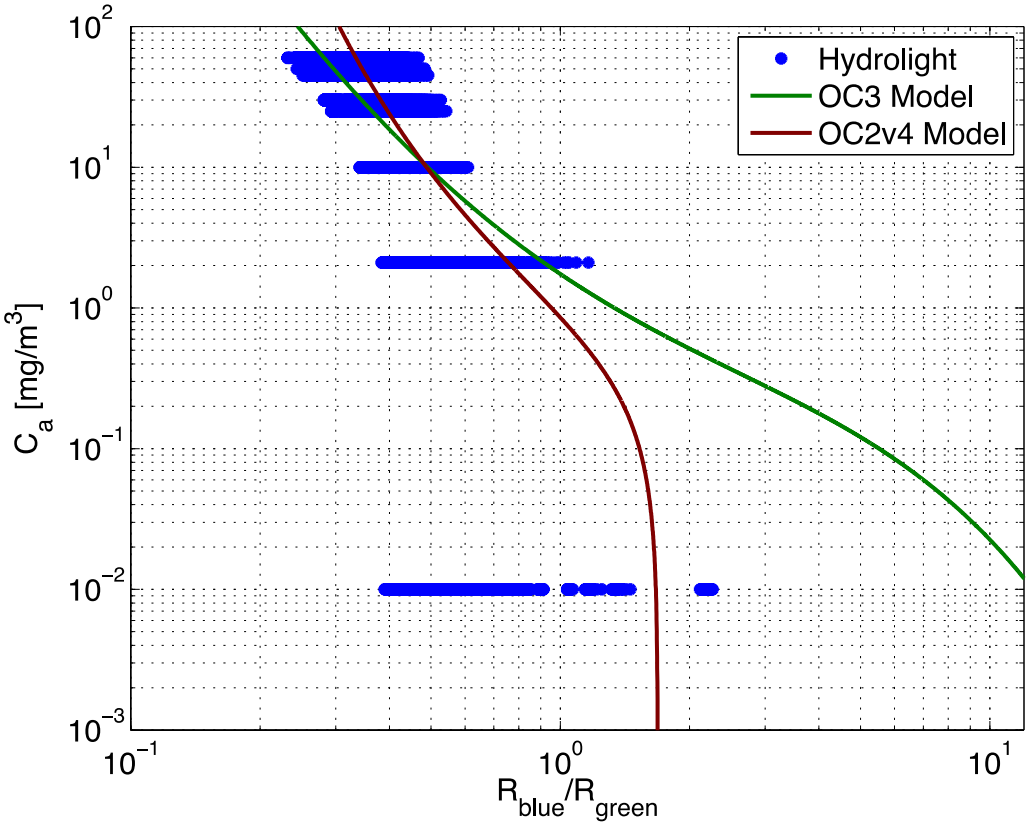


*O'Reilly at al. (2000)

TSS = 0.01 mg/L

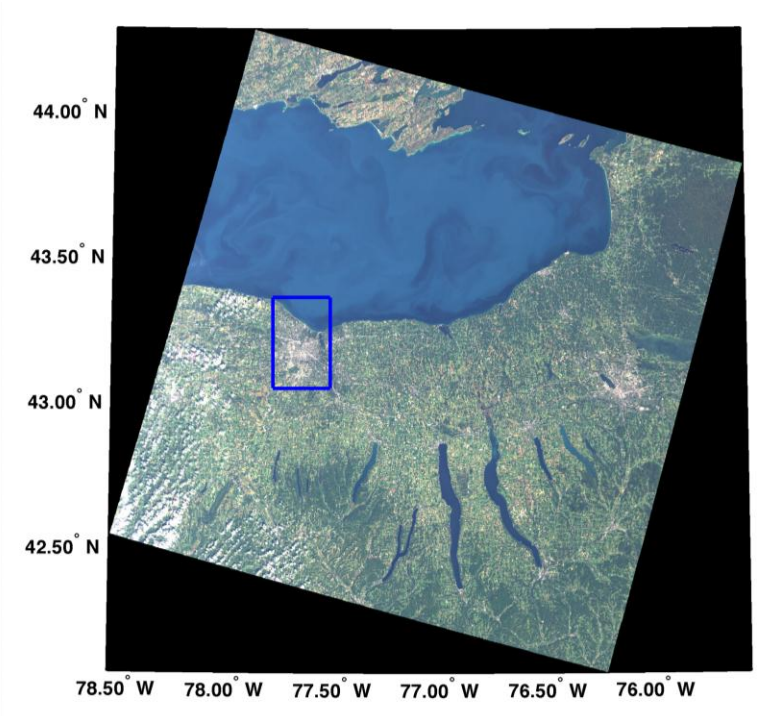
a_CDOM(440)=0.0954 1/m

NASA's OCx Models* vs Hydrolight nothing fixed

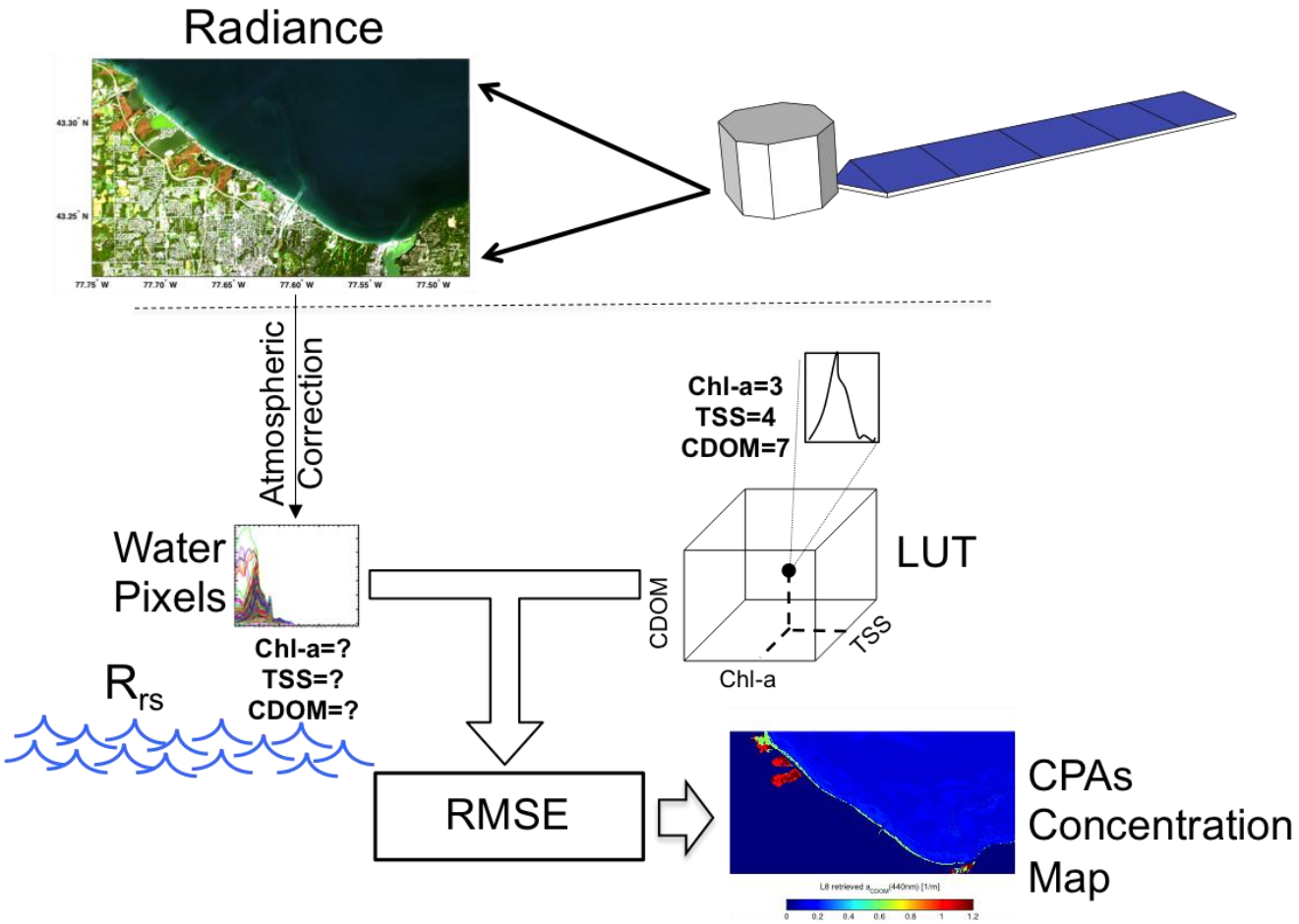


*O'Reilly at al. (2000)

Area of Study



Retrieval

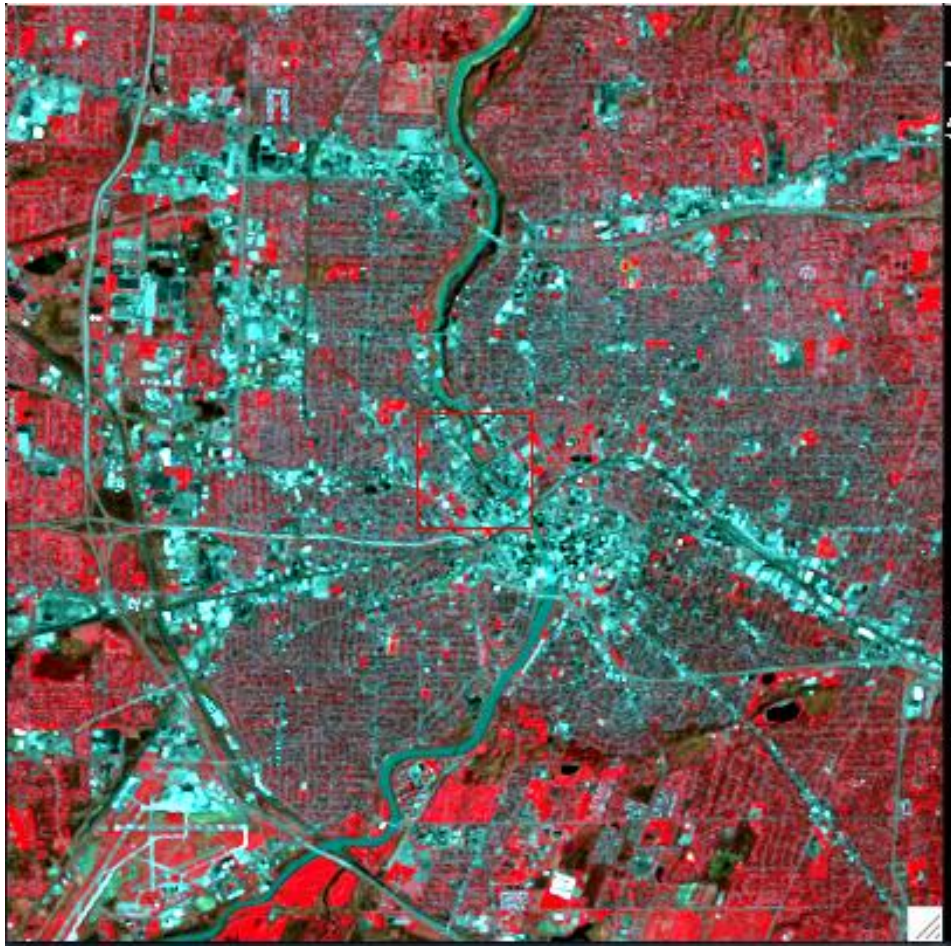

Radiance
43.30° N
43.25° N
77.75° W
77.70° W
77.65° W
77.60° W
77.55° W
77.50° W
Atmospheric Correction
Chl-a=3
TSS=4
CDOM=7
LUT
CDOM
TSS
Chl-a
Water Pixels
Chl-a=?
TSS=?
CDOM=?
R_{rs}
RMSE
CPAs Concentration Map

Empirical Line Method (ELM)

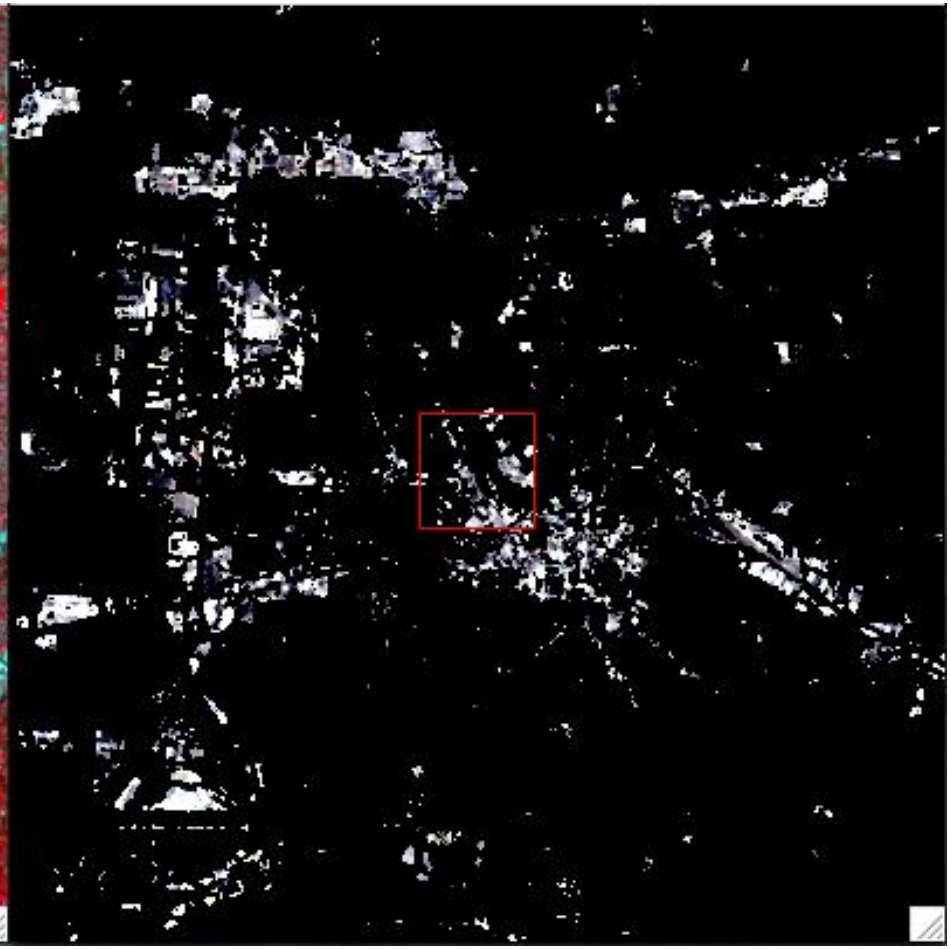
$$L(\lambda) = \frac{E'_S(\lambda) cos(\sigma') r(\lambda) \tau_1(\lambda) \tau_2(\lambda)}{\pi} + \frac{E_{ds}(\lambda) r(\lambda) \tau_2(\lambda)}{\pi} + L_{us}(\lambda)$$

$$L = m \times r_d + b$$

Model-based ELM Method
Bright Pixel

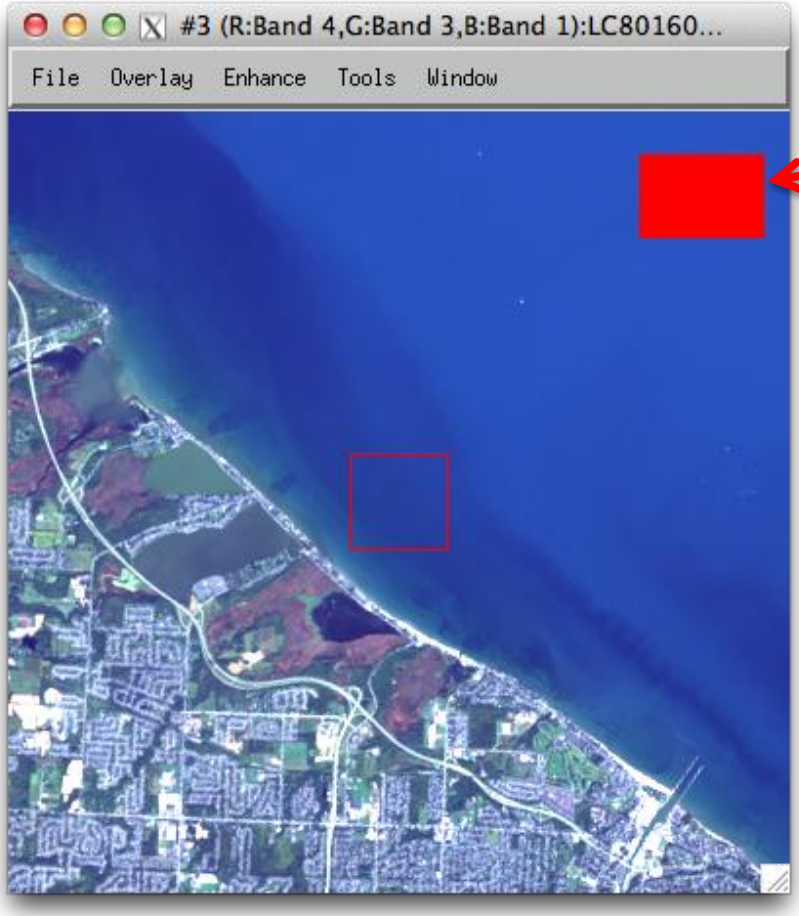


False color image (red = vegetation)

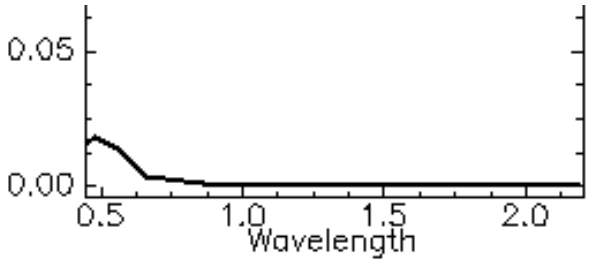


City Pixels (Bright px)

Model-based ELM Method
Dark Pixel



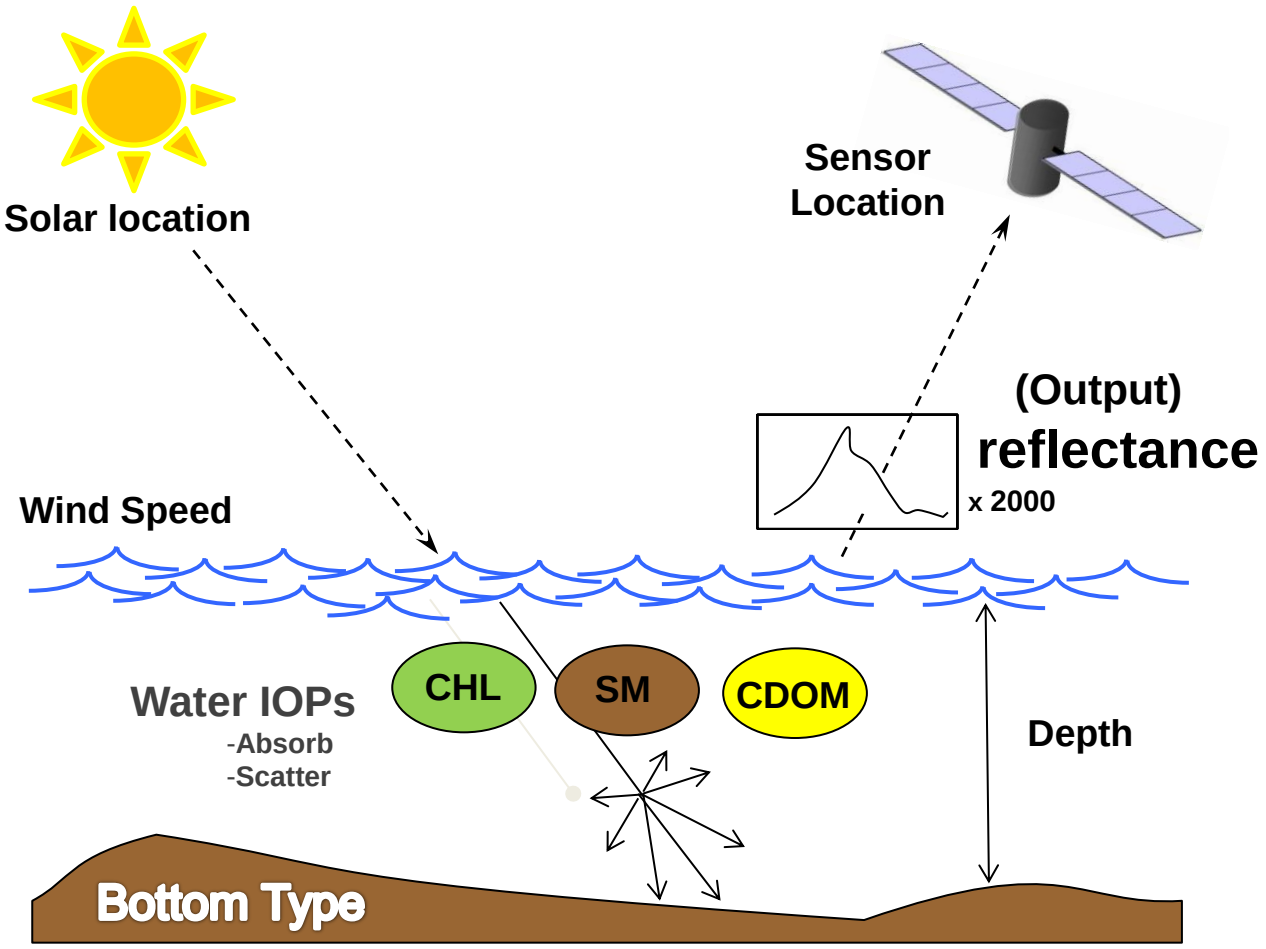
ROI water



Reflectance
HydroLight
For low concentrations

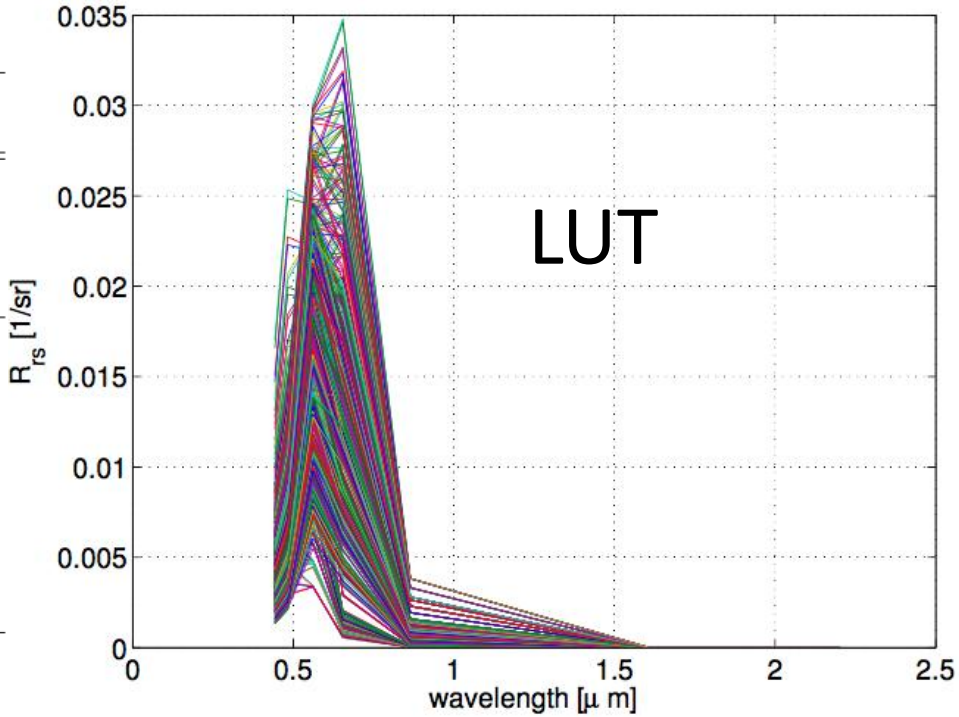
Radiance
Landsat 8 image

HydroLight


Solar location
Sensor
Location
(Output)
reflectance
x 2000
Wind Speed
Water IOPs
-Absorb
-Scatter
CHL
SM
CDOM
Depth
Bottom Type

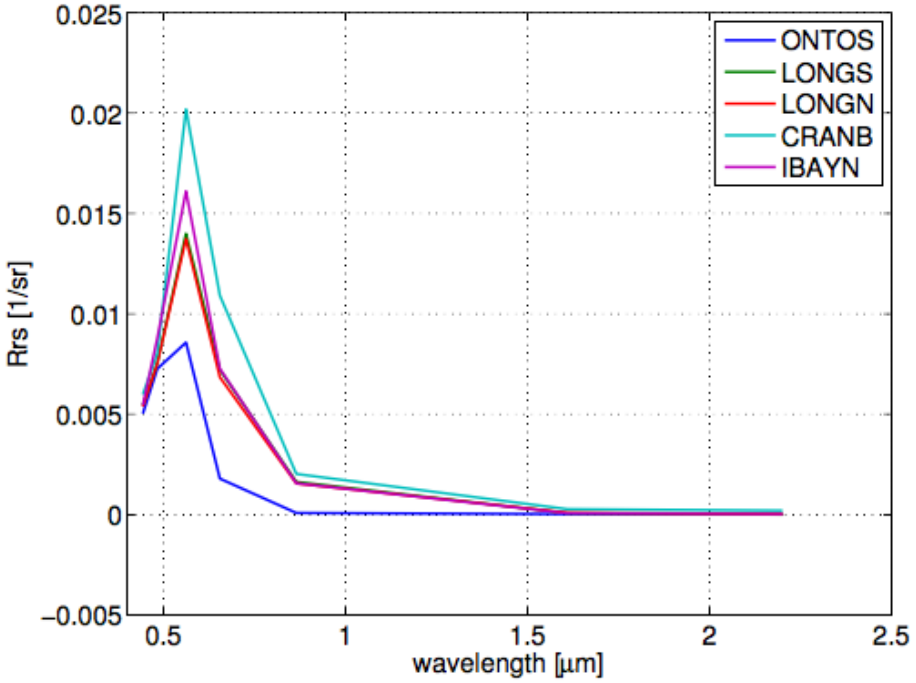
LUT: HydroLight (con't)

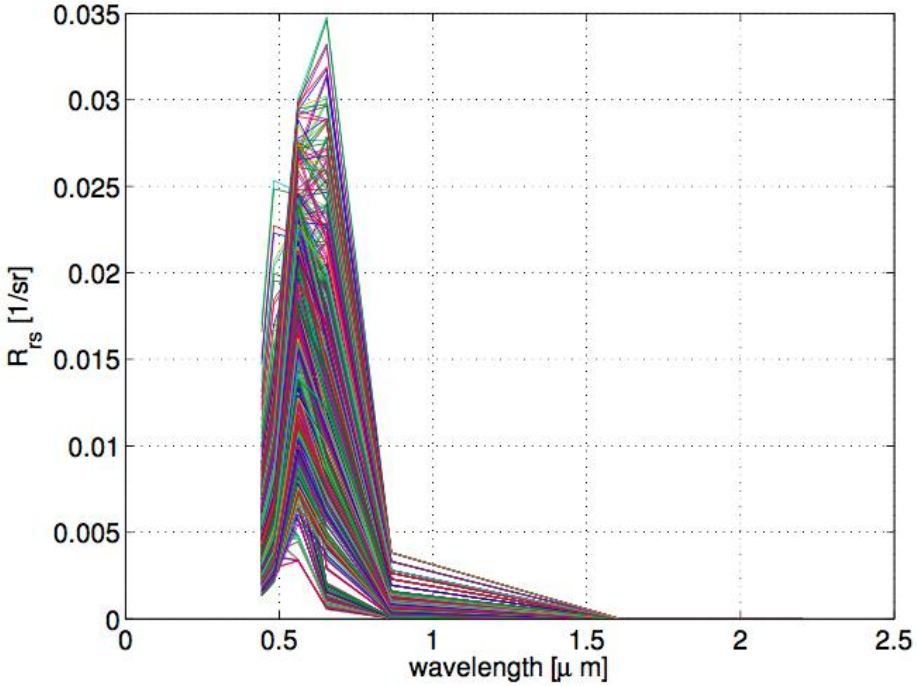
IOPs Input	C_a $[mg\ m^{-3}]$	TSS $[g\ m^{-3}]$	$a_{CDOM}(440nm)$ $[1/m]$	b_b/b [%]
ONTNS	0.1	1.0	0.11	0.5
–	0.5	2.0	0.15	1.0
–	1.0	5.0	0.21	1.5
–	3.0	–	0.6	2.0
LONGS	10.0	10.0	1.0	0.5
–	20.0	25.0	1.2	1.0
–	40.0	45.0	–	1.5
–	60.0	50.0	–	2.0
–	90.0	–	–	–
–	110.0	–	–	–
–	135.0	–	–	–
–	150.0	–	–	–



Known Concentrations

Retrieval: RMSE

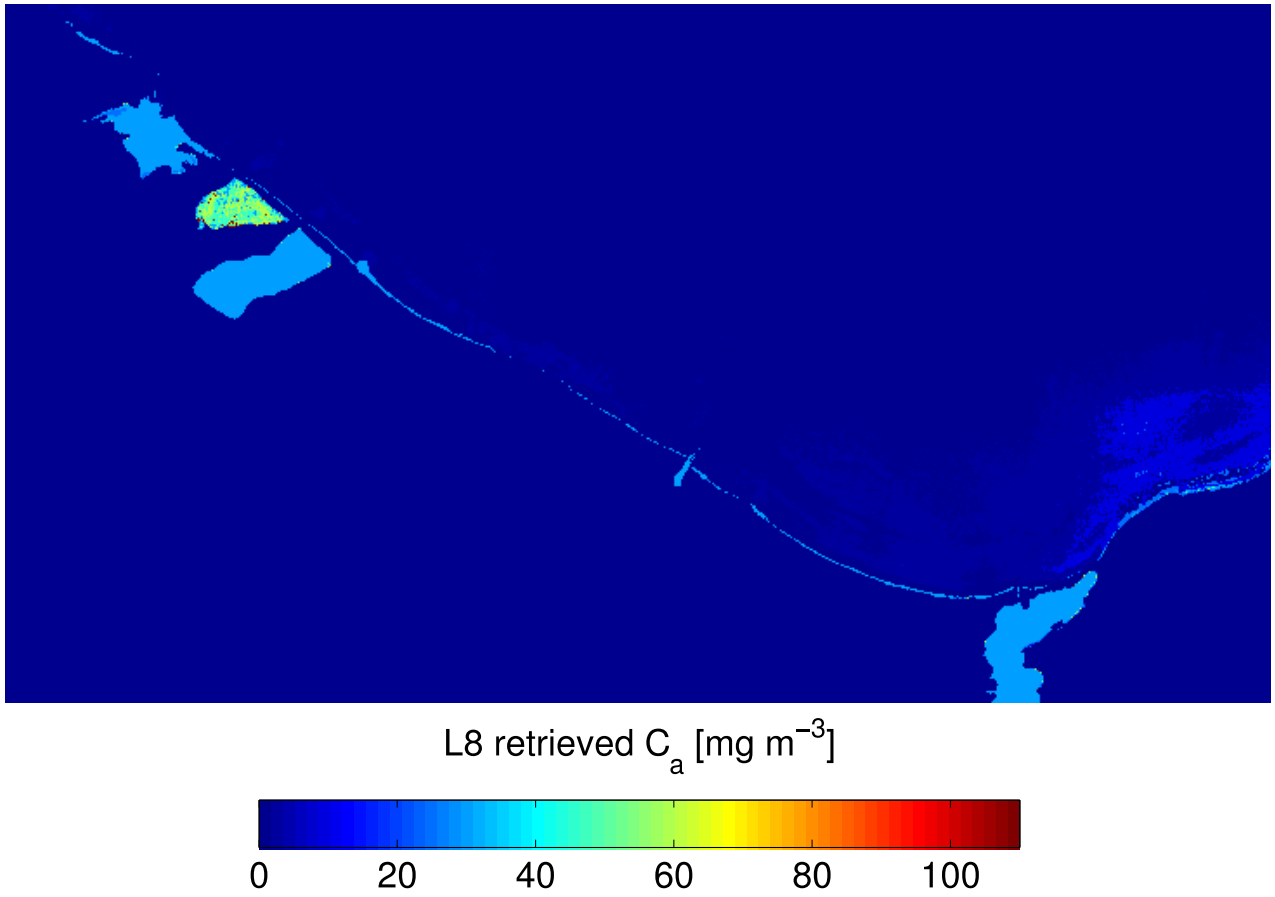




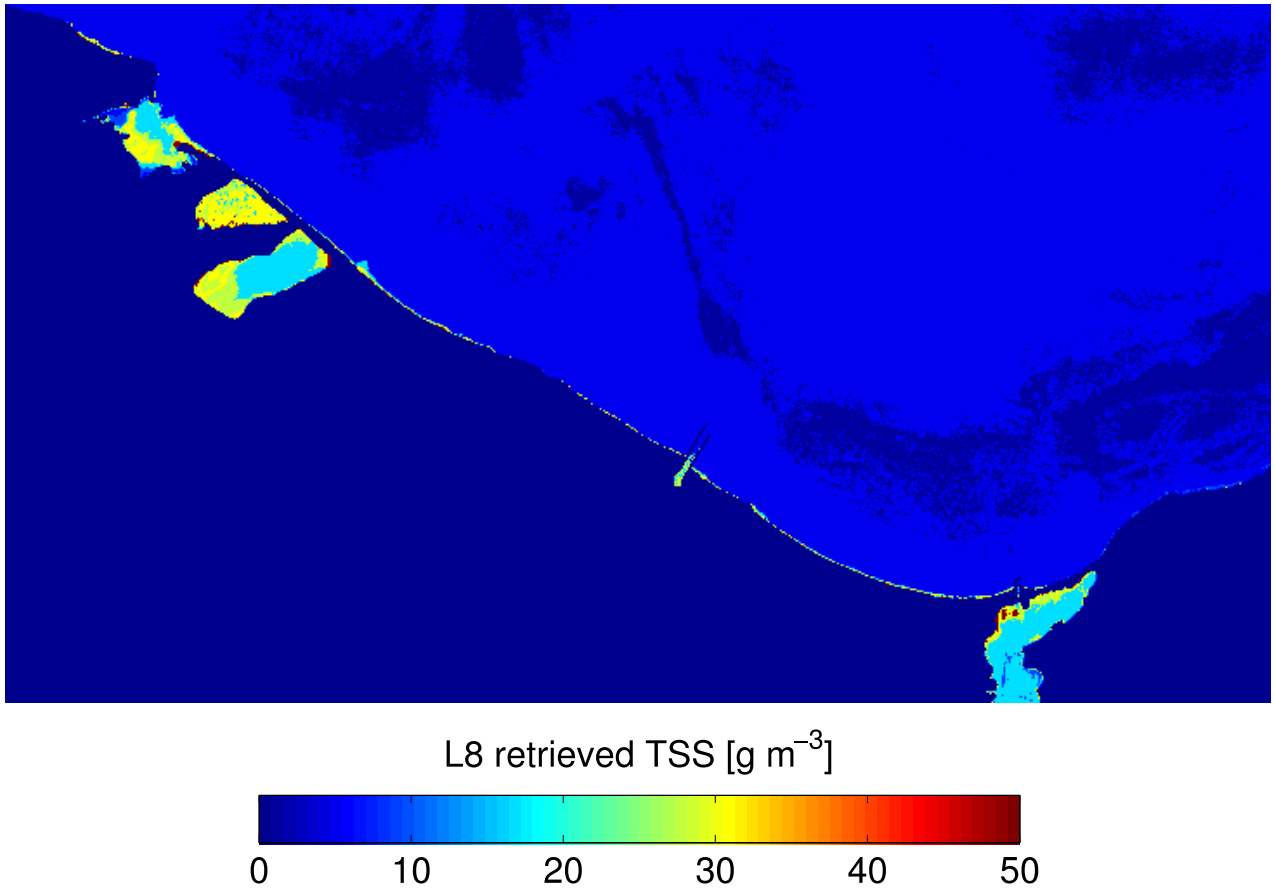
Water Pixels

LUT

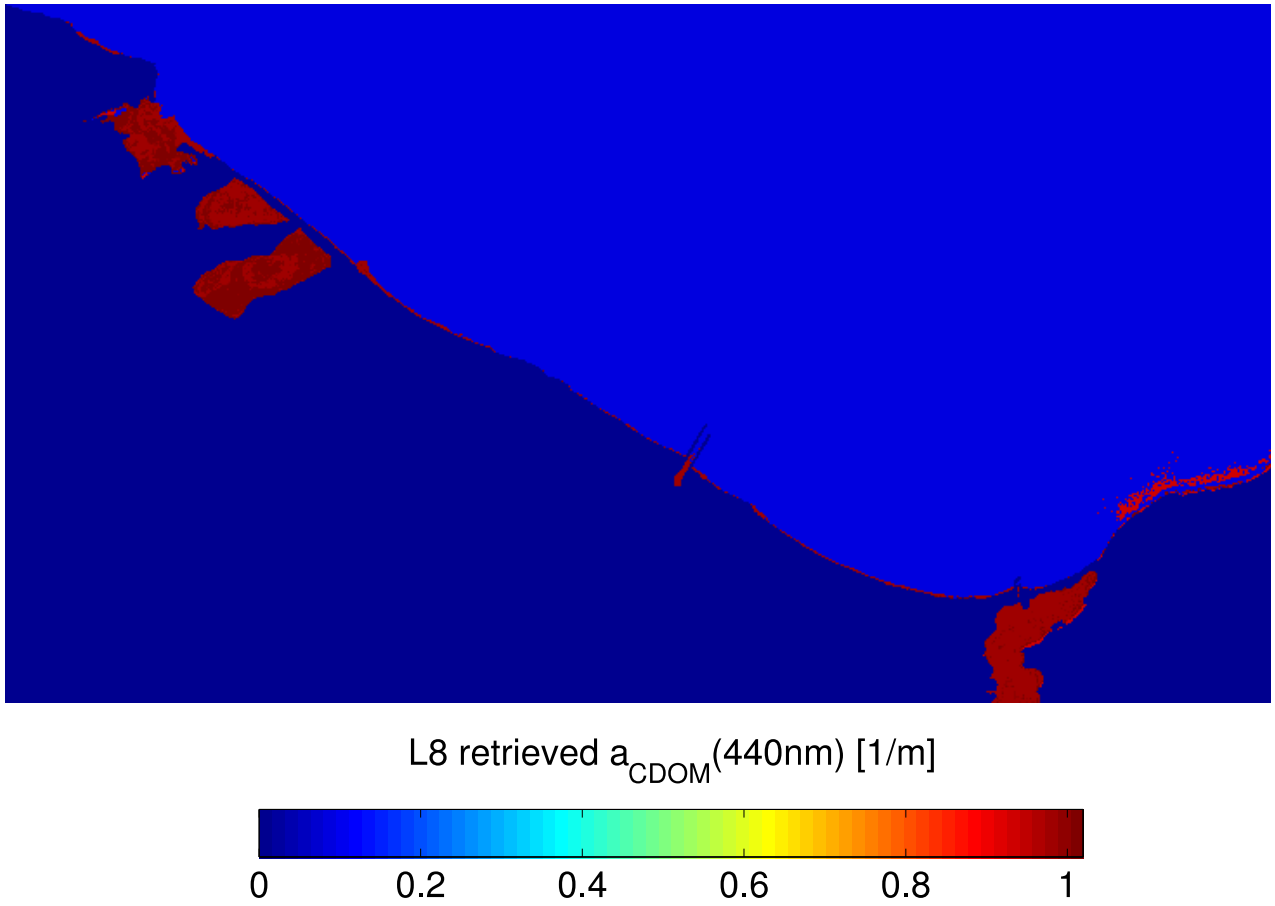
09-29-2014: Chl-a



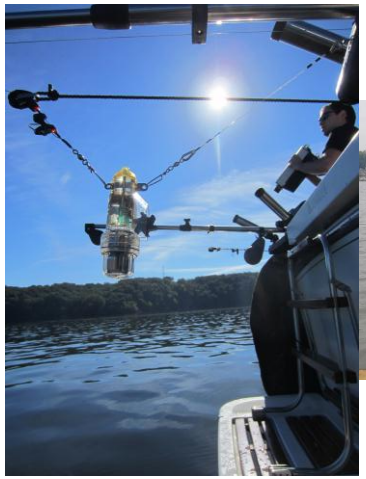
09-29-2014: TSS



09-29-2014: CDOM

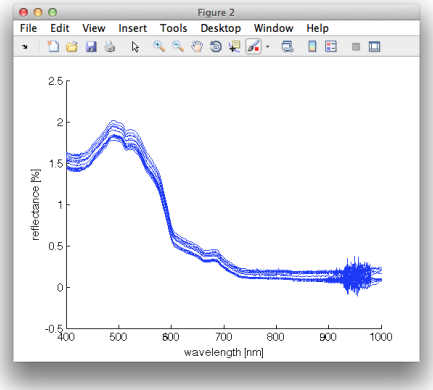


Ground Truth Collect



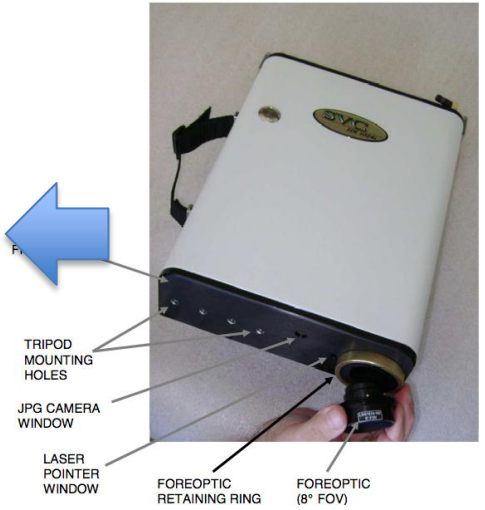
Water Samples

Lab Analysis



Water Leaving Reflectance

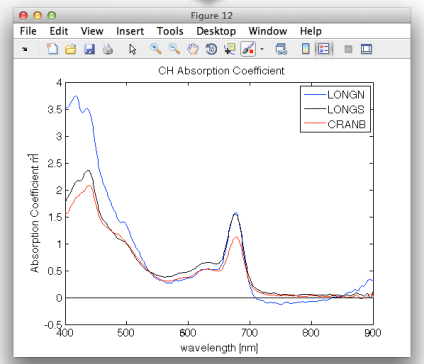
Spectroradiometer



Backscattering

Lab Measurements

Spectrophotometer

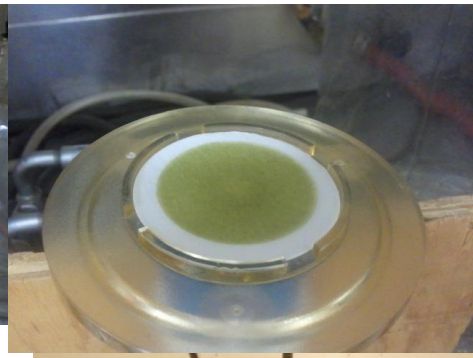


IOPs

HydroLight

Concentrations

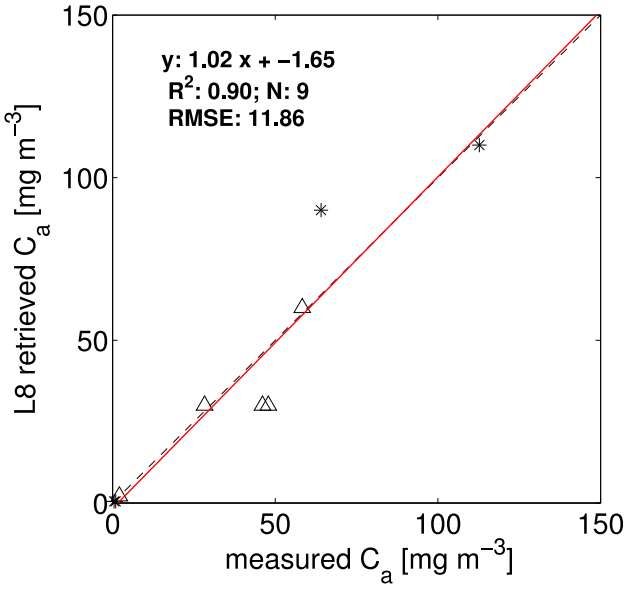
Filtration and Spectophotometric Analysis

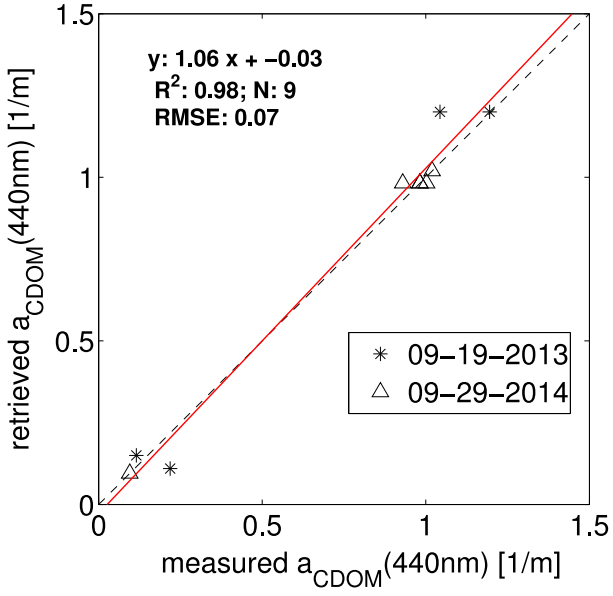


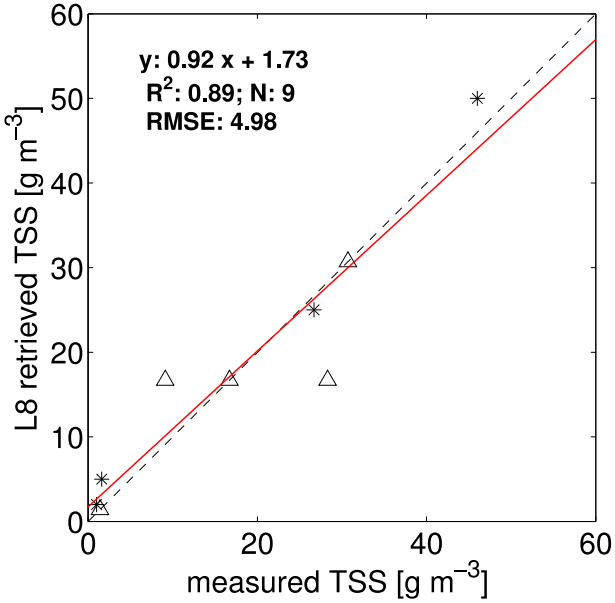
RIT Ground Truth Collection Summary

Date		IOPs		Concentrations		Reflectance		N points	Comments
		Ponds	Lake	Ponds	Lake	Ponds	Lake		
2013	25-Aug	✔	✗	✔	✗	✗	✗		
	19-Sep	✔	✔	✔	✔	✗	✔	4	Clear
	26-Sep	✔	✔	✔	✔	✗	✔	8	Clouds
2014	17-May	✔	✗	✔	✗	✔	✗		
	02-Jun	✗	✔	✗	✔	✗	✔		
	11-Jul	✔	✔	✔	✔	✔	✔	8	Glint
	28-Aug	✗	✔	✗	✔	✗	✗		
	29-Sep	✔	✔	✔	✔	✔	✔	5	Clear
	24-Oct	✔	✗	✔	✗	✗	✗		

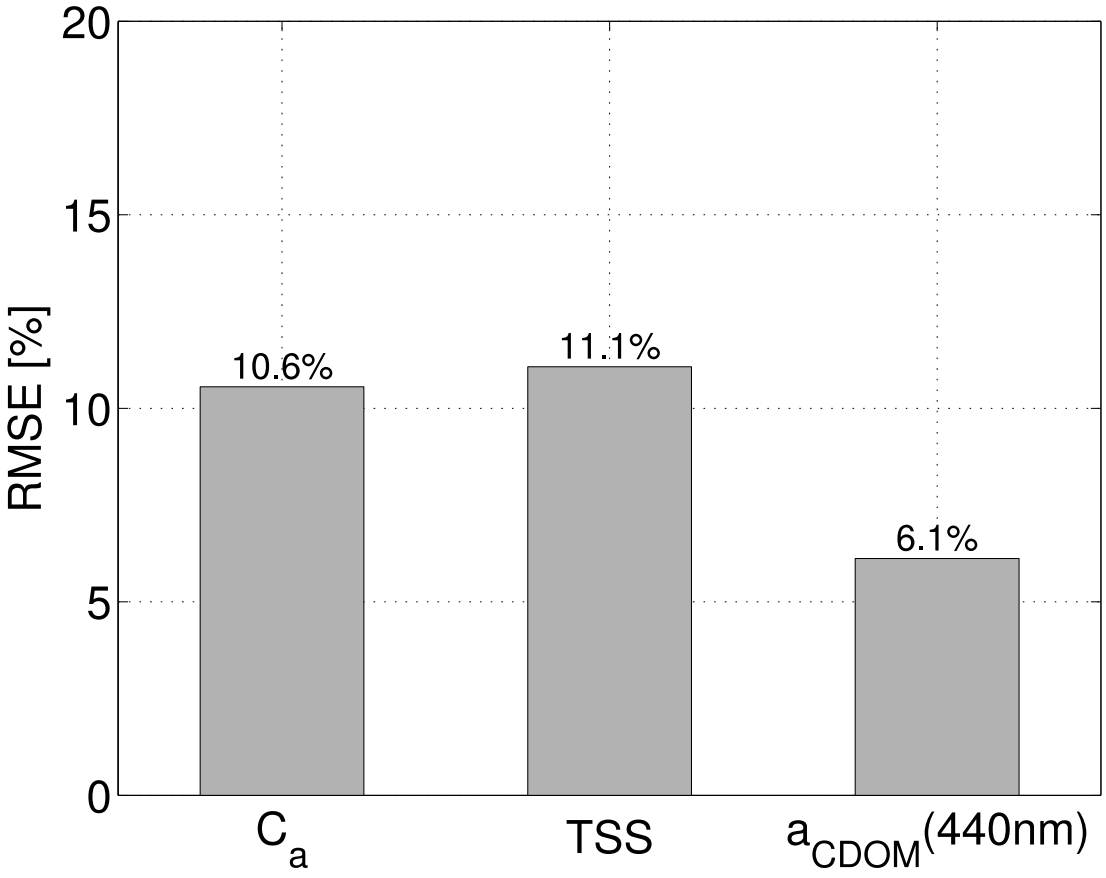
Retrieved vs Measured







Error: RMSE/C_{max}



Future Work

- Include a glint correction
- Try in a different water body
- Validation by comparing with products from ocean color satellites
- Integration with Hydrodynamics models

Thanks for listening!

Question?

Javier Concha: jxc4005@rit.edu

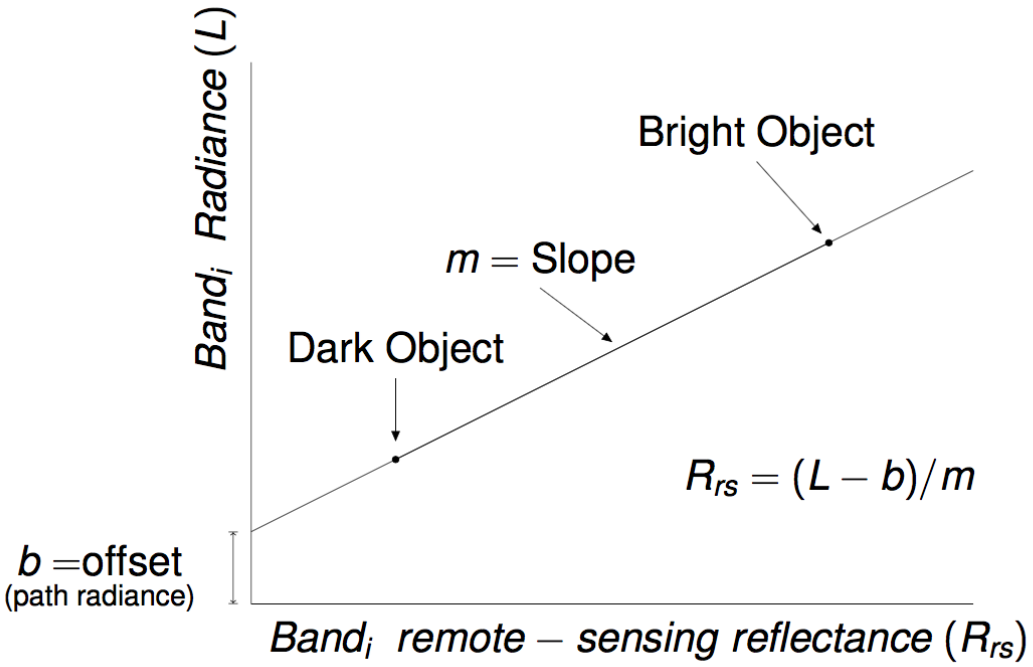
Motivation

- Product not available for medium spatial resolution satellites

- Monitoring the Earth's fresh water supply: Create a water components product for fresh and coastal water

Empirical Line Method (ELM)

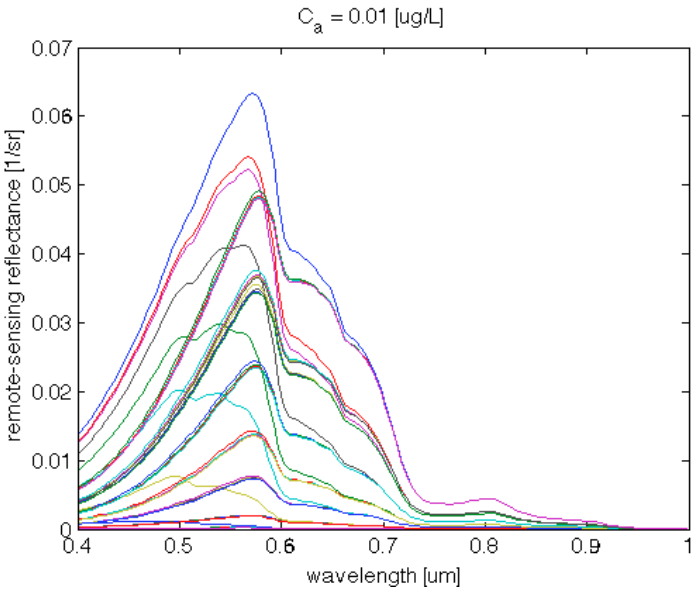
- Two pixels in the scenes with known reflectance
- Linear relationship between radiance L and reflectance R
- Conversion pixel by pixel

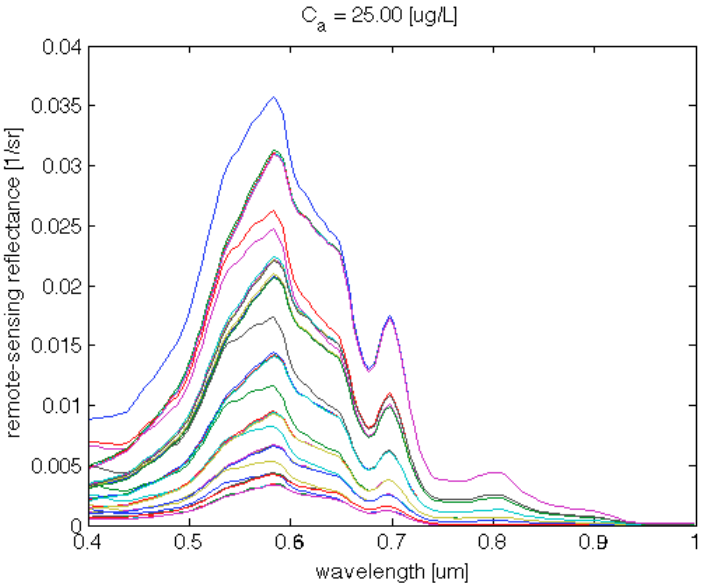


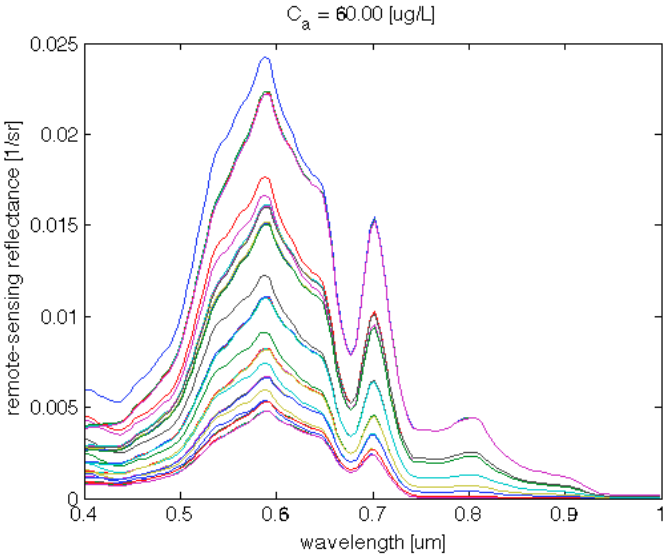
Atmospheric Correction

- A Model-Based Empirical Line Method (ELM) Atmospheric Correction Method
  - Bright pixel :
    - Radiance (Data Spectra): Pseudo Invariant Features (PIF) from L8 image
    - Reflectance (Field Spectra): PIF from Landsat reflectance product (CDR)
  - Dark pixel:
    - Radiance (Data Spectra): water ROI from L8 image
    - Reflectance (Field Spectra): HydroLight (estimated concentration)

Fixed Chl-a
different CDOM and TSS





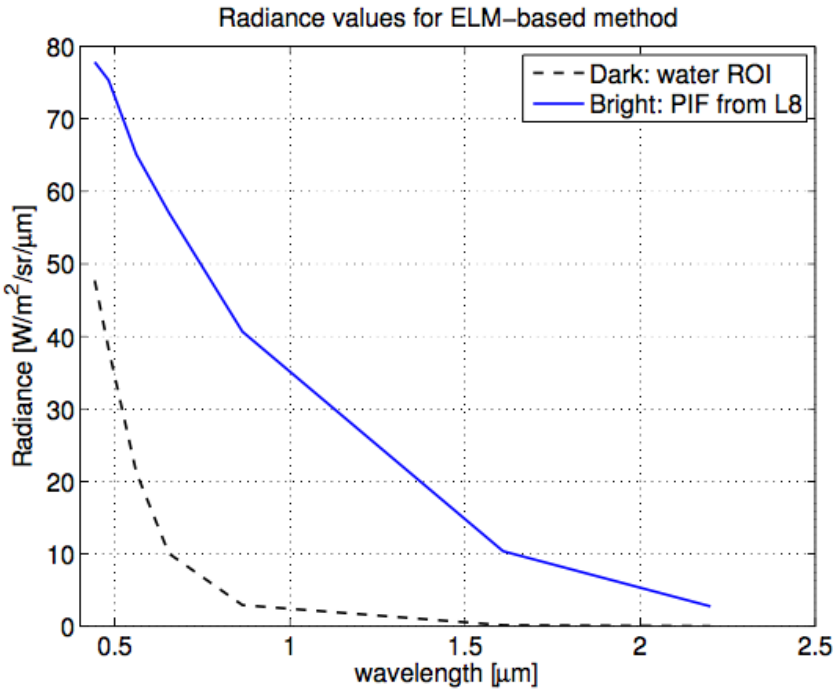


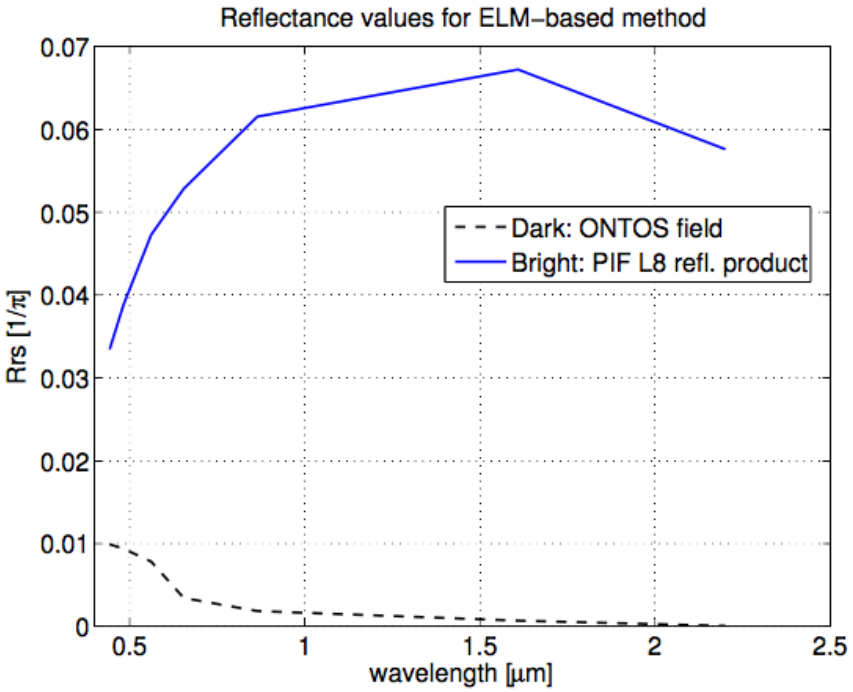
HydroLight

- Case 2: 4-component IOP model
  1. Pure Water
  2. Chlorophyll-bearing particles
  3. CDOM
  4. Mineral Particles

- Output: Water Leaving Reflectance Curves

Model-based ELM Method
Bright and Dark Pixels





Model-based ELM Method